Sborník vědeckých prací Vysoké školy báňské - Technické univerzity Ostrava
číslo 3, rok 2009, ročník LII, řada hutnická,
článek č. 1523

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DMA ANALYSIS OF SPECIAL RUBBER BLENDS

DYNAMICKO – MECHANICKÁ ANALÝZA ŠPECIÁLNYCH GUMÁRENSKÝCH ZMESÍ

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Abstract

This work is deals with dynamic-mechanical analysis of special rubber blends by using of Pyris Diamond (DMA) setup. The work includes description and contain of constituent special rubber blends and description of constituent methods, which were used in measurement. Dynamic – mechanical properties of blends are created by frequency and thermal dependence.

Abstrakt

Práca sa zaoberá dynamicko-mechanickou analýzou gumárenských zmesí pomocou prístroja Pyris Diamond (DMA). Zahŕňa popis a zloženie jednotlivých zmesí a popis jednotlivých metodík použitých pri meraní. Dynamicko mechanické vlastnosti zmesí sú vyhodnotené pomocou frekvenčných a tepelných závislosti.

Key words: rubber blends, carbon nanotubes, DMA method

1. Introduction

By the term rubber mixture is understand the mixture of natural or synthetic caoutchouc with more ingredient, which are used to regulate its workability, can be allow vulcanization and the final properties of vulcanizes are determined. Its quality is one of the basic assumptions to quality rubber product. The particular part of product has different functions and therefore the rubber mixture is various. The final properties are influenced by lot of factors.

During evaluation the influence of factor on dynamic- mechanical properties it can be accentuate, that effect of same factors are linked with each other and it is not possible to expressly quantitative asunder. It can be divided to following group:

Chemical:

- volume and type of used caoutchouc, or combination of caoutchouc,
- stage of reticule and desperation filler,
- type of used additives
- the nature of interaction of filler-filler and caoutchouc-filler,
- stage of mixture filling,
- distribution of stage in system,
- kind of used filler
- interface between caoutchouc and filler.

Physical:

- visco - elastic properties of vulcanizates,
- the temperature of glassily transition,
- the measure conditions,
- the frequency, on which is measurement doing,
- the temperature of measurement,
- the amount of deformation during of measurement.

Application:

- contidions of vulcanizate exploitation (temperature of operation, surroundings, stage of loading.

On this account are the tests of rubber mixure very important during development.

On this paper we observe dynamical-mechanical properties special rubber mixture standard 1 a CNT 1, where in the mixture CNT 1 was dispersed nanoparticules – shape of nanotube.

Carbon nanotubes – their properties and structure

Carbon nanotubes are molecules consist of area graphite, which are rolling to long roller closed on the both ending. [1, 2].

The main characteristic of carbon nanotubes are:

- roller shape,
- superlative slenderness ratio (long a few tens of μm/ diameter lower than 2nm,
- characteristic set-up of hexagon with consideration on self axle, named chiralite
- semiconductive or metallic behaviour on considering chiralite,
- the possibilities of easy formation long roll caused by Van der Waalsovými strengths,
- the potential to chemical modification

The list of physical or mechanical properties CNT shows, that they can throw which-ever concurrency in certain applications [3, 4].

Table 1 The list of physical or mechanical properties of nanotubes.

Properies	CNT	Comparison
Size	d = (0,6 – 1,8) nm	Photolitoghy offers diameter bigger than 50 nm
Density	1,33 – 1,4 g.cm^{-3}	Density of aluminium je 2,7 g.cm^{-3}
Tensile strength	45 GPa	Steel cca 2 GPa
Max. current density	1013 A.m^{-2}	Molten cupper wires 1010A.m^{-2}
Heat-transmission value (20°C)	6000 W.m^{-1}.K^{-1}	Diameter – 3320 W.m^{-1}.K^{-1}
Melting	2800°C –vacuum 750°C – air	Aluminium – 660°C on the air

2. Experimental part

The principle of DMA method

The basis of device for dynamic-mechanical analysis (DMA) are two collinear arms, Arms are placed on special pivots, which are located in the middle of arms. Pivots are very exact torsion springs. The specimen is clamped in special holder between two collinear arms.

The device is situated in thermostatic environment, which enable to isothermal measure and to measure during changing of temperature, usually from 150 to 500°C. The deformations of sample are caused by two opposed moments the same size, which are impact on opposite end of sample clamped to the clamp.

By DMA we can characterize polymer material, its dependence of modulus, stupor or losing angle tan δ on temperature, possibly on time at various frequencies. So we obtain basic information about mechanical properties, which are related to processability and applicability of product.

We used the testes apparatus by PerkinElmer „PYRIS Diamond Dynamic Mechanical Analyzer (DMA) for measure dynamical-mechanic properties.

Dynamical tensile test we did during time program from 20°C to 100°C. We gradually applied frequencies 0.01 Hz, 0.05 Hz, 0.2 Hz, 0.5 Hz, 1 Hz, 5 Hz, 10 Hz, 20 Hz and 50 Hz. On Fig.1-6 we evaluated our measurements.

Table 2 Chemical contains of rubber mixture standard 1 a CNT 1

Components	Dose in DSK	
	standard	CNT 1
NR	100	100
N660	27,6	27,6
ZnO	2,1	2,1
Gumodex	3,4	13,8
sulphur	2,7	2,7
accelerator	0,7	0,7
CNT	–	1,63

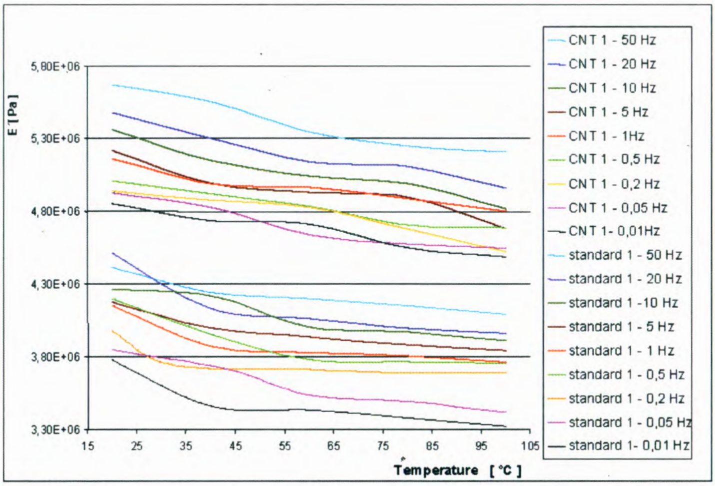

Fig. 1 Comparison of dependence E′ on the temperature samples standard 1 a CNT 1 by various frequencies

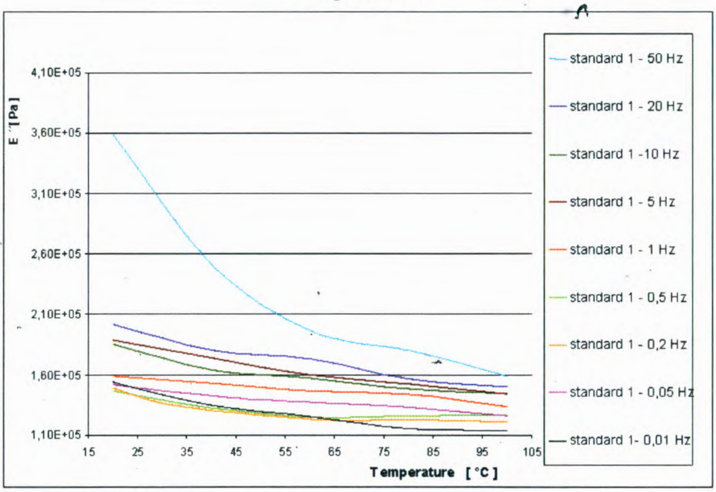

Fig. 2 Comparison of dependence E′′ on the temperature sample standard 1 by various frequencies

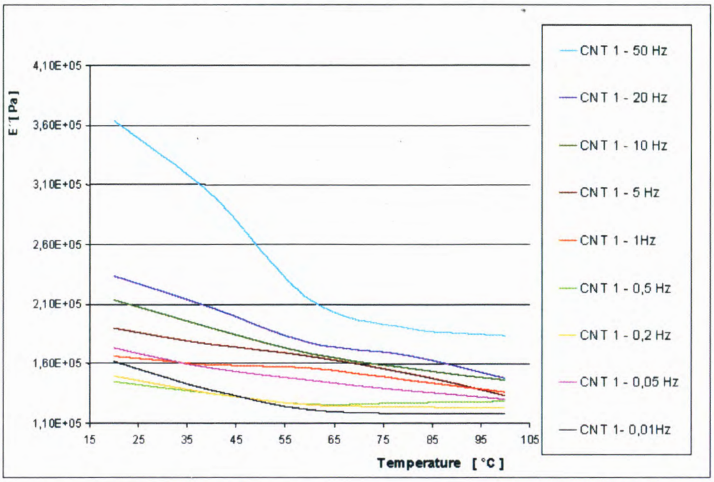

Fig. 3 Comparison of dependence E′′ on the temperature sample CNT 1 by various frequencies

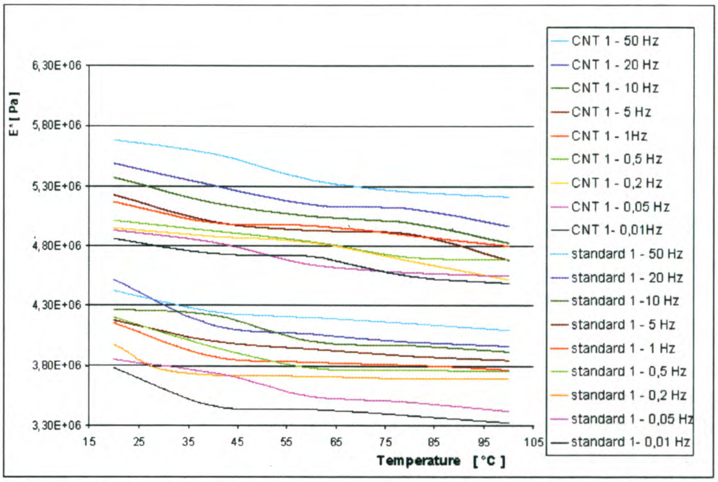

Fig. 4 Comparison of dependence E* on the temperature samples standard 1 a CNT 1 by various frequencies

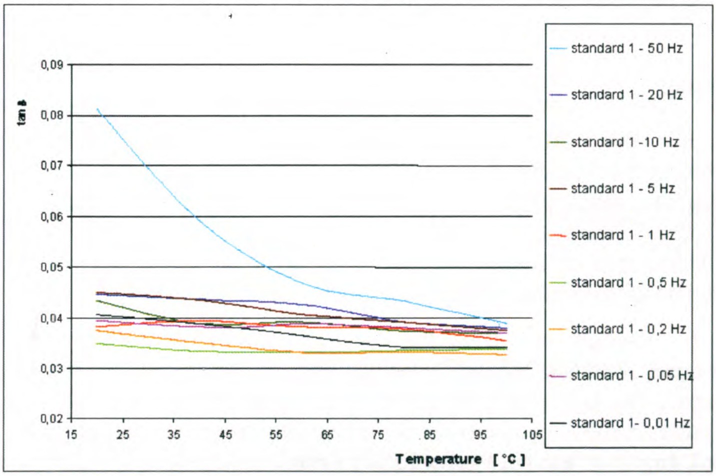

Fig. 5 Comparison of dependence tan δ on the temperature sample standard 1 by various frequencies

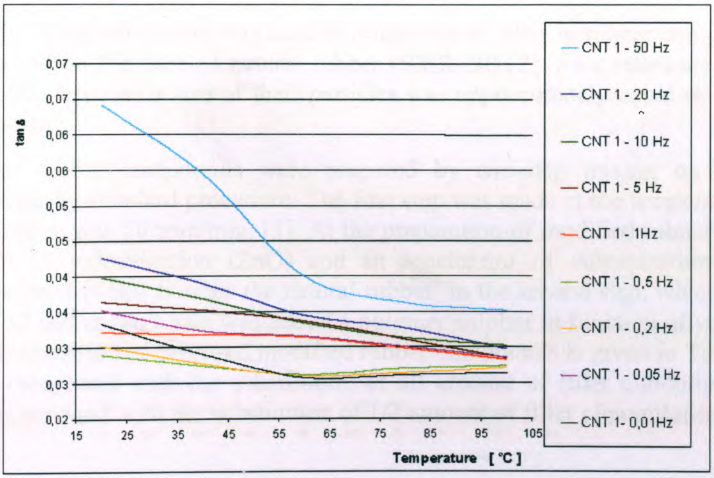

Fig. 6 Comparison of dependence tan δ on the temperature sample CNT 1 by various frequencies

3. Results

From the graphic dependence of real number of modulus elasticity E′ (Fig. 1), imaginarily number modulus elasticity E′′ (Fig. 2,3) and complex modulus elasticity E* (Fig. 4) it can be seen, that values modulus elasticity are decreasing with increasing temperature and values of modulus elasticity are increased with increased

From the dependence (Fig. 5,6) tan δ o temperature it can be seen, that with increasing temperature values tan δ are decreasing and with increasing frequency are values tan δ increasing.

The results from the comparison samles 1 and CNT1 (in the samples was dispersed nanoparticules – the shape of nanotubes):

- the values real part of modulus of elasticity E′ in the sample wit nanotubes markedly increased,
- elasticity of sample was improve (Fig. 1),
- values if imaginary part of modulusu of elasticity E′′ did not have shinind changes, so viscous, loss part of complex modulus of elaticivity did not change (Fig. 2,3),
- values complex modulus of elasticivity E* was encreased -nanotubes improved mechanical properties of rubber mixture (Fig. 4),
- values tan δ on the sample CNT 1 go down, so decreased adherence in wet and decreased rolling-resistance force (Fig. 5,6).

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